

Commercial Space Development – What's the Next?

ESMD Technology Exchange Conference

Robert M. Kelso
Manager, Commercial Space Development
NASA–JSC, Commercial Crew/Cargo Program
November 15, 2007

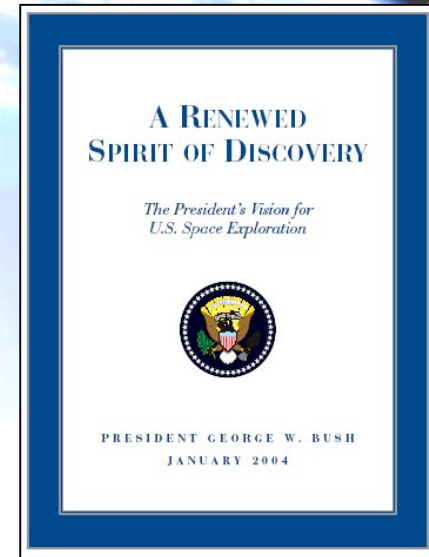


National Direction



- **National Space Exploration Policy/
Vision for Space Exploration, Jan 2004**

- *[The United States will] Promote...
commercial participation in exploration...
to further U.S. scientific, security, and economic interests.*
- *[The NASA Administrator will] Pursue
**commercial opportunities for providing transportation
and other services supporting the International Space Station
and exploration missions beyond low Earth orbit.***



- **NASA Authorization Act of 2005**

- *The Administrator shall establish a program to develop a sustained human presence on the Moon...
to promote exploration, science, commerce...*
- *The Administrator... **shall develop a commercialization plan** to support the human missions to the Moon and Mars, to support low-Earth orbit activities...*

- **NASA Administrator Mike Griffin,
American Astronautical Society, Nov. 15, 2005**



- *If we are to make the expansion and development of the space frontier an integral part of what it is that societies do, then these activities must, as quickly as possible, assume an economic dimension as well... To this end, it is up to us at NASA to use the challenge of the Vision for Space Exploration to **foster the commercial opportunities** which are inherent to this exciting endeavor.*

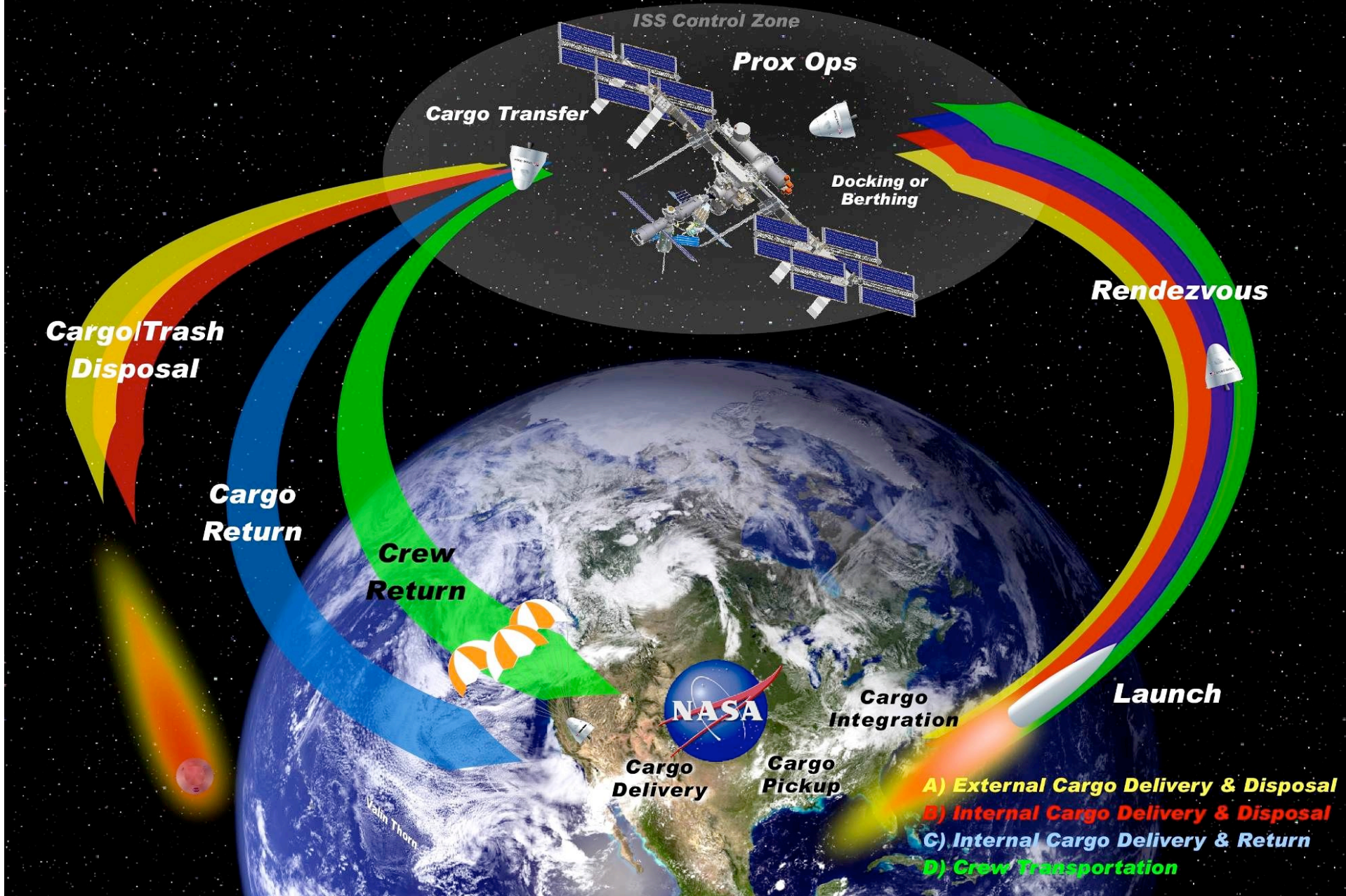
Program Objectives



- The Commercial Crew & Cargo Program Office (C3PO) has been established at the Johnson Space Center to accomplish the following objectives:
 - *Implement U.S. Space Exploration policy with investments to stimulate the commercial space industry*
 - *Facilitate U.S. private industry demonstration of cargo and crew space transportation capabilities with the goal of achieving safe, reliable, cost effective access to low-Earth orbit*
 - *Create a market environment in which commercial space transportation services are available to Government and private sector customers*

NASA Commercial Crew & Cargo Program

Commercial Orbital Transportation Services



COTS Innovative Features



- \$500M budgeted in FY06-FY10 as an *investment* for the demonstration of commercial orbital transportation capabilities
- COTS Project executed in two phases:
 - Phase 1: Technical Development/Demonstration funded Space Act Agreements (SAA)
 - Phase 2: Competitive Procurement of Orbital Transportation Services
- Phase 1 competition executed Jan-Aug 2006
- Phase 1 SAAs include an *option* for crew transportation demonstrations
 - Pending successful cargo demonstrations *and* additional NASA funding
- Phase 2 planning has been initiated within NASA to support the procurement of ISS commercial cargo services by 2010

COTS Phase 1 is NOT a procurement or contract for products and services – It is NASA's catalyst for commercial capability demonstrations where the potential high return on investment outweighs the associated financial risk

COTS Innovative Features



- **Phase 1 Competition**
 - Utilized NASA's Space Act authority vs. FAR contract
 - Emphasized management team skills vs. company past performance
 - Business plan and financial criteria similar to private investment models
 - Broadly targeted technical goals for the general space transportation market
 - Firm requirements/processes where necessary for ISS certification and human safety
 - Encouraged private investment to share costs, enable multiple awards, and maximize capability coverage
- **Space Act Agreement**
 - Companies retain maximum rights to intellectual and personal property allowed by law
 - FAA licensing and cross-waiver liability provisions
 - Fixed-price performance milestone payments
 - Series of incremental milestones based on objective criteria
 - Restricted termination provisions

*COTS is a Government-Industry partnership
paving a new way of doing business with the private sector*

COTS Participants

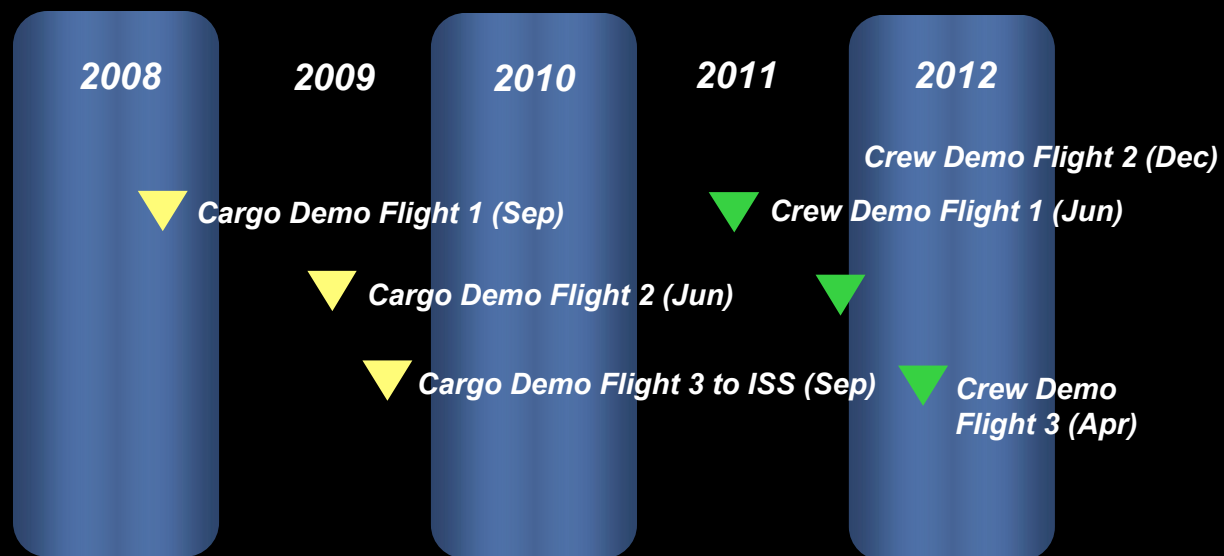


- Received 21 proposals from 20 companies across the full spectrum of industry
- Down selected to 6 companies for final evaluation and negotiations – 2 selected for portfolio of funded SAAs
 - Andrews Space
 - SpaceDev
 - SPACEHAB
 - Transformational Space Corp. (t/Space)
 - **Space Exploration Technologies (SpaceX)**
 - **Rocketplane Kistler (RpK)***
 - Currently being re-competed

\$ Funded Space Act Agreement \$

\$ Funded Space Act Agreement \$

COTS Flight Demonstrations



Funded Milestone

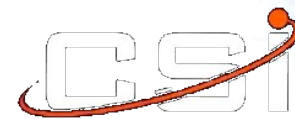


Optional Milestone

Other Commercial Partnerships

● Nonreimbursable (unfunded) SAAs enabling NASA technical assistance with space transportation capability development have been signed with five companies :

- SpaceDev
- SPACEHAB
- PlanetSpace
- Transformational Space Corp. (t/Space)
- Constellation Service International (CSI)



Fundamental Change for NASA



Apollo Model

From NASA as the customer funding prime contractors on a cost plus fixed fee basis



Insufficient Government Resources

Open Architecture: Infrastructure
Open for Potential External Cooperation

- Lander and ascent vehicle
- EVA system
 - CEV and Initial Surface capability
 - Long duration surface suit
- Power
 - Basic power
 - Augmented
- Habitation
- Mobility
 - Basic rover
 - Pressurized rover
 - Other: mules, regolith moving, module unloading
- Navigation and Communication
 - Basic mission support
 - Augmented
 - High bandwidth
- ISRU
 - Characterization
 - Demos
 - Production

Robotic Missions

- LRO- Remote sensing and map development
- Basic environmental data
- Flight system validation (Descent and landing)
- Lander
- Small sats
- Rovers
- Instrumentation
- Materials identification and characterization for ISRU
- ISRU demonstration
- ISRU Production
- Parallel missions

Logistics Resupply

- Drills, scoops, sample handling, arms
- Logistics rover
- Instrumentation
- Components
- Sample return

Specific Capabilities

- Drills, scoops, sample handling, arms
- Logistics rover
- Instrumentation
- Components
- Sample return

US/NASA Developed hardware

17

COTS Model

To NASA as a customer and partner, working with other customers, financiers, and emerging space companies on fixed price basis to secure capabilities, services and products

NASA Investor Model Summary



NASA Investor Model				
Description	Std. Govt Contract	Govt. Commercial Leverage	Corporate VC	Commercial VC
Primary Motivation	Meet Govt. Need	Technology demonstration, Cost Avoidance	Strategic leverage, Supply Chain, \$	\$ Return on Investment
Risk Sensitivity	Risk adverse	Willing to take some risk	Accept moderate to high levels of risk	Accept high levels of risk
Technology Maturity	>TRL 7	TRL 3-6	TRL 3-7	>TRL 6
Time To Exit	2-5 years typical	3-7 years	7 years max	7 yrs max
Funding Levels	unlimited	a few hundred thousand up to \$300 million	a few million up to \$50 million over multiple rounds	a few million to \$20 million over multiple rounds (and sometimes far higher)
Success Metrics	Procurement of goods and services to fulfill mission	Technology Demonstration for Mission Enhancement, Cost Avoidance	Strategic, Supply Chain ROI >30-50% For large corporations ROI > \$100M	\$, ROI >10x
Mgt. Philosophy	Earned value, lots of reports and paperwork	Limited oversight, focus on results	More hands-off possibly observer on BOD	Typically very hands-on, seat on BOD
Critical factors for success	Delivery to gov't set specifications	Solid external business model, solid government service need	Strategic alignment (product adjacency), "passionate advocate"	Solid management team (even more than IP)
Downsides	Government policy instability	Limited number of previous models, perceived risk to gov't	Investment \$ instability; subject to quarterly bottom line	Project deliverables highly tied to VC funding rounds

Open Architecture: Infrastructure Open for Potential External Cooperation

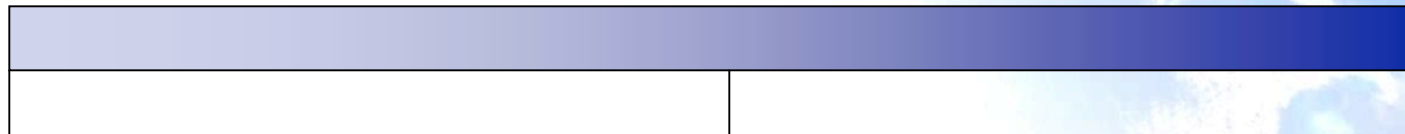
- **Lander and ascent vehicle**
- **EVA system**
 - CEV and Initial Surface capability
 - Long duration surface suit
- **Power**
 - Basic power
 - Augmented
- **Habitation**
- **Mobility**
 - Basic rover
 - Pressurized rover
 - Other, mules, regolith moving, module unloading
- **Navigation and Communication**
 - Basic mission support
 - Augmented
 - High bandwidth
- **ISRU**
 - Characterization
 - Demos
 - Production
- **Robotic Missions**
 - LRO- Remote sensing and map development
 - Basic environmental data
 - Flight system validation (Descent and landing)
 - Lander
 - Small sats
 - Rovers
 - Instrumentation
 - Materials identification and characterization for ISRU
 - ISRU demonstration
 - ISRU Production
 - Parallel missions
- **Logistics Resupply**
- **Specific Capabilities**
 - Drills, scoops, sample handling, arms
 - Logistics rover
 - Instrumentation
 - Components
 - Sample return

** US/NASA Developed hardware

Options for Commercial Participation in NASA Missions



Spectrum of Options for Commercial Participation



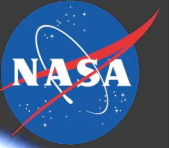
Centennial
Challenges
(*Commercial
funded and
managed*)

Lunar Exploration
Science Campaign -
Regular Small Missions
to the Moon
(*Hybrid model - NASA and
commercial funding and
management*)

Lunar
Precursor
Robotic
Program
(*NASA funded
and managed*)

- Lunar Comm/Nav
- Lunar Micro-Landers
- Lunar Observatories
- Lunar Sample Return (e.g. dust)
- ISS National Lab Science
- Earth Observations
- Sub-Orbital Observations
- Free Flyers

Potential Lunar Missions



Science

- Lunar meteoroid impact dating
- Lunar seismic monitoring
- Lunar observatories
- In-situ dust characterization
- Small sample (mg) return

Technology

- Lunar descent/ascent module design
- Lunar dust characterization
- Lunar communication and infrastructure
- Power beaming
- Habitat design
- Surface mobility

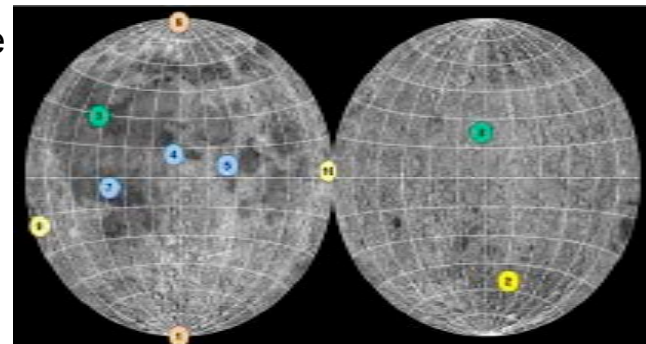
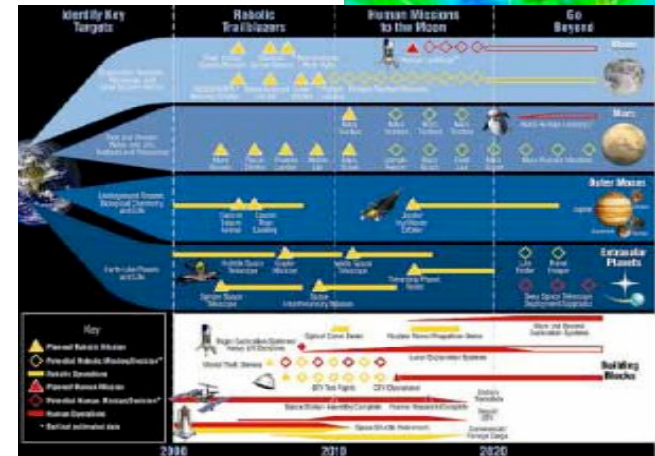
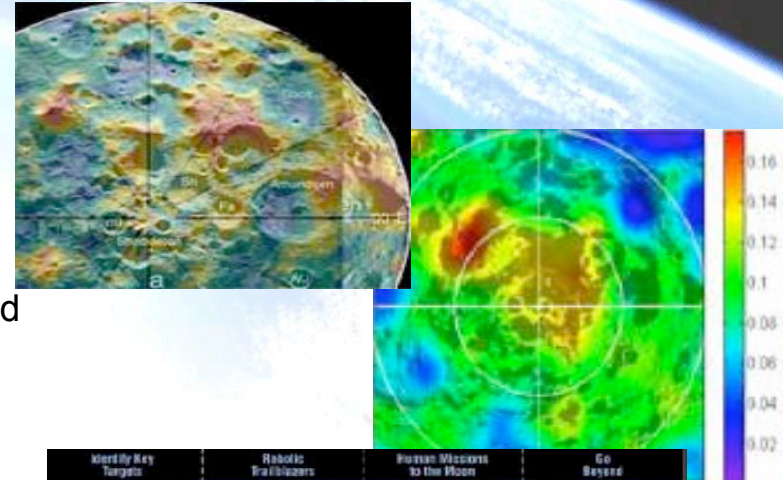
Commercial

- Communication nodes and infrastructure
- Power and mobility infrastructure
- Cargo transport services
- Entertainment and education
- Observatories

Why Robotic Scientific Exploration?



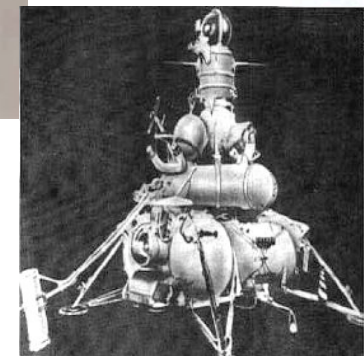
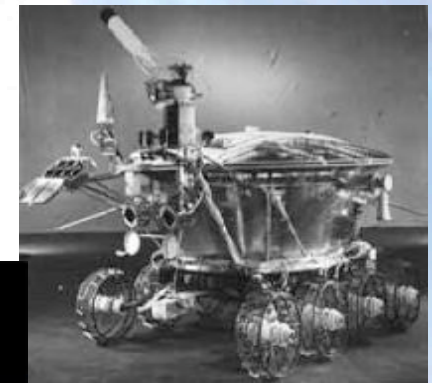
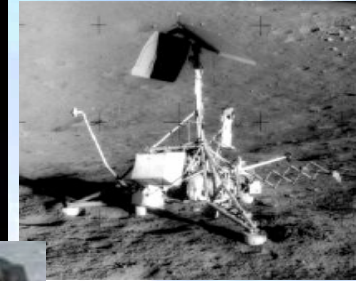
- **Strategic knowledge**
 - Important information on lunar environment and materials
 - Scientific and operational reconnaissance
 - Obtain information on unknown or poorly understood processes and history (e.g., polar deposits)
 - Reconnoiter areas and sites to make subsequent human exploration more productive
- **Sustain the Vision for Space Exploration**
 - Decade between LRO and first human landings
 - Sustain program with cadence of visible milestones
- **Emplacement of assets**
 - Pre-landed machines can prepare site, emplace equipment for later human use



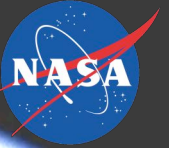
Types of robotic missions



- **Impactors (hard landers)**
 - **Ranger**; Nested data of increasing resolution.
- **Soft landers**
 - **Surveyor**; Point landings and in situ measurements
- **Surface stations**
 - **Far UV spectrograph**; observe and measure from a point
- **Rovers**
 - **Lunakhod**; traverse and measure in situ
- **Networks**
 - **ALSEP**; instruments laid out over wide area to measure in tandem
- **Sample returns**
 - **Luna**; collect

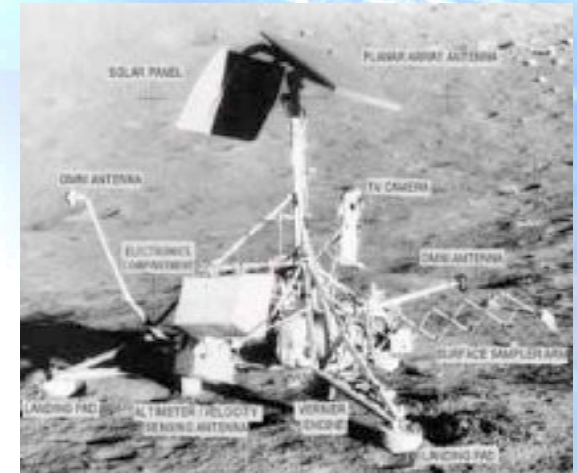


Site specific landers



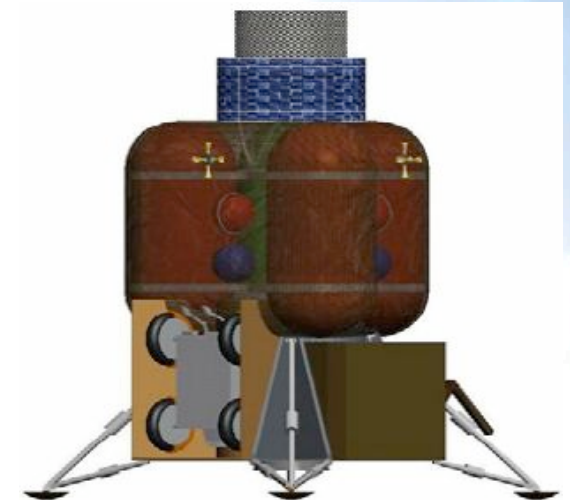
Simple landers (100-200 kg class)

- Surveyor-class; could carry up to 30-40 kg payloads
- Visual surveys, soil analysis, geotechnical properties, small ISRU demos



Larger Landers (>300 kg class)

- All of the above, plus deployment of a mobility device
- Rover could determine spatial extent of compositional variability
- Should carry mechanism to sample subsurface (up to ~2 m depth)



COMMERCIAL CREW & CARGO

RETURN TO THE LUNAR SURFACE

Lunar Exploration Science Campaign

Next COTS Project?



Possible Scenario for Lunar Science

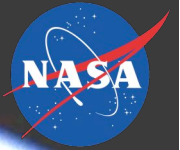


- (1) Establishing an aggressive lunar science campaign to the lunar surface**
- (2) Enabled by commercial leveraging with NASA**
- (3) Leading to a near-term technology demonstration on the surface.**



Source: Carnegie Mellon University

Key Points for the Lunar Campaign

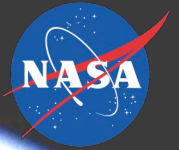


- Small (\$50-100M)
- Frequent, multiple flights
- Commercially-leveraged: Open Competition for lunar services
- NASA/LPI/LEAG could define the science and campaign
- NASA Ames could provide small-sat expertise and sample return
- Industry provide the “Fed-Ex” to the surface
- Could address technology-risk reduction
- Infrastructure development (comm)

Commercial interest in the moon is growing....

- Question: **can we use this interest to leverage lunar science and exploration goals? The resulting in a public/private partnership could increase science return, lower net costs, while achieving commercial objectives for industry.**

How could the NASA/Commercial-leverage model help?



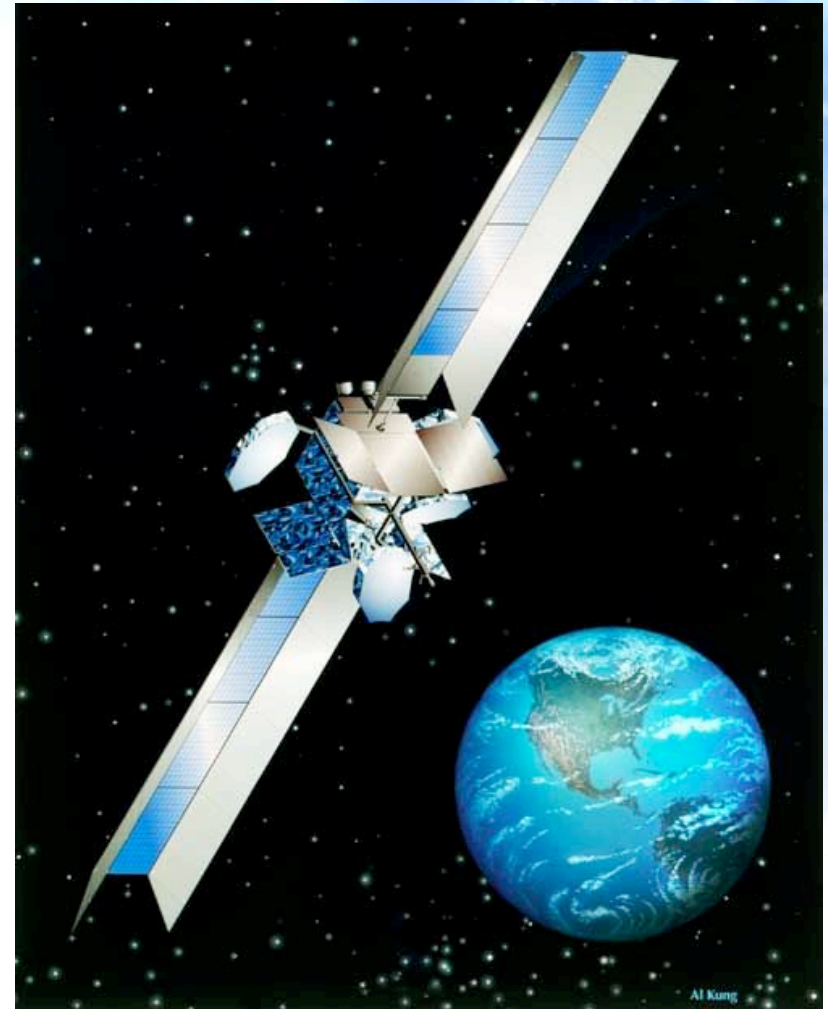
Relative to the lunar science campaign, it is felt that this business model could be critical to:

- **Enabling the campaign (sooner than later...)**
- **Enabling global science on the moon**
- **Enabling ESMD risk reduction**
- **Enabling more commercial opportunities relative to the moon. (ex: lunar commercial communications).**
- **Getting more public interest and participation**

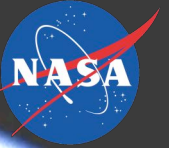
"Commercial Services" for Lunar Communications



- A unique opportunity for NASA & industry collaboration to provide important infrastructure supporting VSE
 - open standards
 - COTS
 - new services
- *Significant potential for sale of commercial services to NASA and other customers*



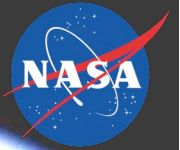
ISS National Lab



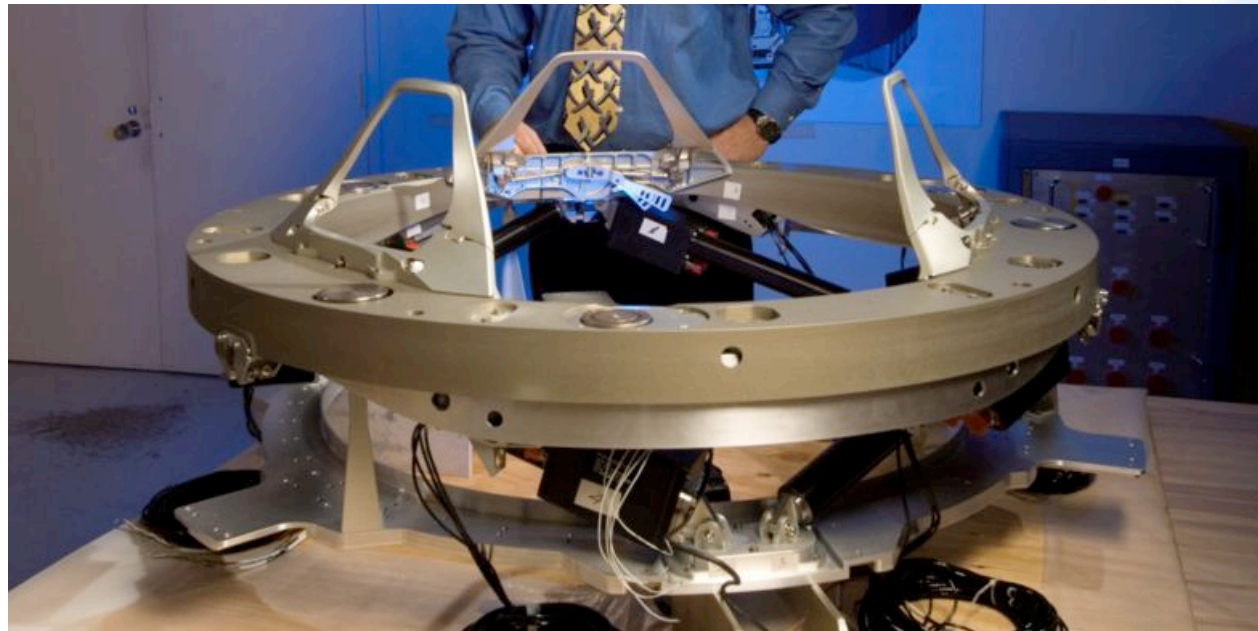
- Workshop held October 2nd thru 4th, 2007 at the NASA Ames Research Center
- Chaired by Nobel Laureate Baruch Blumberg and keynote by William Gerstenmaier, AA/SOMD
- *Purpose: identify and develop ISS National Lab demand by identifying and crafting the pioneering investigations that establish the ISS as the first national laboratory beyond Earth*



Low Impact Docking System (LIDS)



- **Informal discussion with industry relative to docking systems**
 - Meeting between both industry and government to discuss where we are all going relative to docking systems and standards.
 - Include both the service buyer side and the potential supplier side (industry).



Other Business Segments that may apply to this commercial partnership model

- **Lunar Surface Habitats**
- **Power on Lunar Surface**
- **Free-flyer science platforms in low-earth orbit**
- **Suborbital flights for microgravity science**
- **Bio / crew health**
- **Lunar Surface Mobility**



Summary



- U.S. space policy directs pursuit of commercial opportunities for providing transportation and other services to low Earth orbit and beyond
- NASA's Commercial Crew & Cargo Program established to implement policy with significant investments to stimulate the commercial space industry
- COTS significantly reduced barriers to entry to enable entrepreneurial approaches for the commercial space transportation market

Successful use of the commercial-leveraged model will lead to other investments to stimulate the commercial space industry and providers ...leading to other, new space markets as we look toward the Moon - a new era for commercial space

A New Era In Spaceflight Is Beginning...



COMMERCIAL
CREW & CARGO

